

CHROMOSOMES OF FIVE NORTH AMERICAN BUTEONINE HAWKS

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ABSTRACT.—Five species of buteonine hawks were karyotyped for the first time, including the Swainson's Hawk (*Buteo swainsoni*), Gray Hawk (*B. nitidus*), Ferruginous Hawk (*B. regalis*), Harris' Hawk (*Parabuteo unicinctus*), and Broad-winged Hawk (*B. platypterus*). All five species have 68 chromosomes. The karyotypes of the first four species appear to be very similar to each other and to other buteos reported previously in the literature, differing in the shape of only one chromosome. The Broad-winged Hawk karyotype differs in the morphology of several chromosomes.

Cromosomas de cinco especies norteamericanas de halcones del género *Buteo*

RESUMEN.—Por primera vez han sido examinados y caracterizados los cariotipos de cinco halcones del género *Buteo* (Aguililla Migratoria Mayor *Buteo swainsoni*, Aguililla Gris *B. nitidus*, Aguililla Real *B. regalis*, Aguililla Rojinegra *Parabuteo unicinctus*, y Aguililla Migratoria Menor *B. platypterus*). Todas las cinco especies tienen 68 cromosomas. Parece ser que los cariotipos de halcones de las cuatro primeras especies (*B. swainsoni*, *B. nitidus*, *B. regalis*, y *Parabuteo unicinctus*) son muy similares entre ellos, así como lo son con los de otros halcones de este género ya referidos en literatura anterior. Éstos se diferencian sólo por la forma de sólo un cromosoma, mientras que el Aguililla Migratoria Menor difiere por la morfología de varios cromosomas.

[Traducción de Eudoxio Paredes-Ruiz]

Chromosome analysis has been used to study phylogenetic relationships in several species, such as falcons (Schmutz and Oliphant 1987) and owls (Schmutz and Moker 1991). In our view, cytogenetics is well suited to cladistic analysis because the phylogenies are based on centric fusions (Robertsonian translocations) and inversions (White 1973, Hsu 1979), both of which also impair fertility (Therman 1980, Diedrich et al. 1983, Lippman-Hand and Vekemans 1983), part of the classical definition of species separation.

In an ongoing attempt to collect cytogenetic data on raptors for this purpose, we have karyotyped five species of buteonine hawks not previously reported. The five species of hawks are the Swainson's Hawk (*Buteo swainsoni*), Gray Hawk (*B. nitidus*), Ferruginous Hawk (*B. regalis*), Harris' Hawk (*Parabuteo unicinctus*), and Broad-winged Hawk (*B. platypterus*).

Prior to our study, five other species of buteos had been karyotyped. These were the Common Buzzard (*B. buteo*; Renzoni and Vegni-Talluri 1966, De Boer 1976), the Red-tailed Hawk (*B. jamaicensis*; Shoffner 1974, Pape and Ogasawara 1978, Stock and Worthen 1980), the Rough-legged Hawk (*B. lago-*

pus; Bulatova 1977), the Roadside Hawk (*B. mag-nirostris*; de Lucca 1983), and the White-tailed Hawk (*B. albicaudatus*; de Lucca 1985).

MATERIALS AND METHODS

The blood sample from the Ferruginous Hawk was collected in Alberta, Canada. Blood samples from the Harris' and four Gray Hawks were collected in Arizona. The blood samples from the Swainson's Hawk and the Broad-winged Hawk were collected from birds in captivity for rehabilitation at the Western College of Veterinary Medicine after injury near Saskatoon, Saskatchewan, Canada.

Lymphocyte cultures were established from 0.5 ml of whole blood and chromosomes prepared as described by Schmutz and Oliphant (1987). Karyotypes were based on the best metaphase(s) obtained on complete cells. Several cells were photographed and the chromosomes arranged. Comparative studies of karyotypes not done in our own lab are based upon figures in the original published papers when available or photocopies through interlibrary loan.

RESULTS

Although most bird species have a large number of microchromosomes and few macrochromosomes, the hawks and eagles are atypical in that few of their chromosomes could be called microchromosomes. The Swainson's Hawk (Fig. 1), Gray Hawk (Fig. 2),

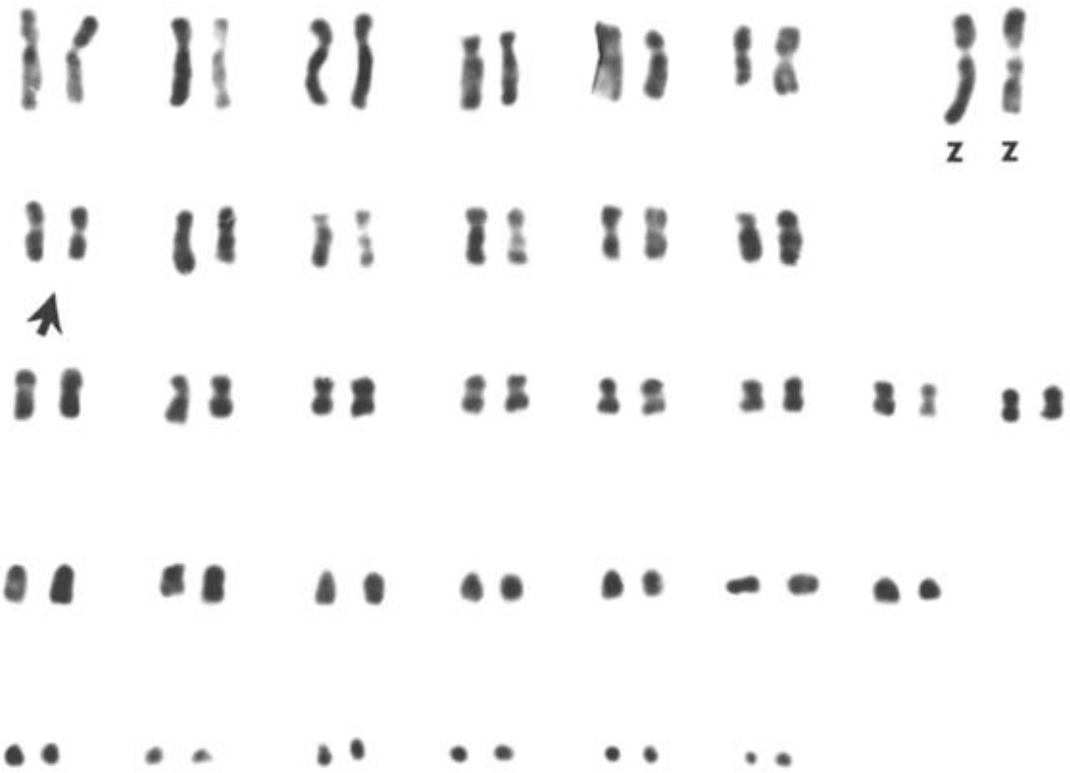


Figure 1. The karyotype of a male Swainson's Hawk (*Buteo swainsoni*) with an arrow marking chromosome 7, the variable chromosome which is metacentric in this species.

Ferruginous Hawk (Fig. 3), and Harris' Hawk (Fig. 4) each had 68 chromosomes including one large metacentric pair (the sex chromosomes), five large submetacentric pairs, six medium-sized metacentric pairs, eight small metacentric pairs, and 13 small acrocentric pairs, and one pair which was variable in morphology. This variable chromosome was either a large submetacentric or large acrocentric. It was the seventh largest by size and therefore we refer to it as chromosome 7. Traditionally chromosomes are grouped by centromere position and then secondarily by size. We have decided to arrange the chromosomes for ease of comparison among the species, in the traditional order for the Swainson's Hawk and Common Buzzard but with chromosome 7 out of its traditional place for the other species. Other authors, such as Stock and Worthen (1980) who have published only a single species karyotype, place this chromosome with the other acrocentrics so it would be number 21 in their karyotype.

The Broad-winged hawk differed from the other four hawks we studied although the total number remained 68 (Fig. 5). The largest pair was again metacentric and we presume it to be the sex chromosome pair. However, there were only 16 submetacentric or metacentric pairs in total as opposed to 20-21 pairs.

We subdivided the buteonine hawks into two major groups based on the different morphologies of chromosome 7 (Fig. 6) and placed *B. platypterus* in a third separate group since chromosomes 16-20 differed. Although the karyotype of the Gray Hawk (Fig. 2) does not have an obvious acrocentric chromosome 7, it is the clearest karyotype overall and therefore we chose to publish it. Other karyotypes we studied clearly indicate that chromosome 7 is acrocentric in this species. Less clear, is the morphology of chromosome 20 which also appears acrocentric in this photograph (Fig. 2).

We attempted to include the other buteo species



Figure 2. The karyotype of a male Gray Hawk (*Buteo nitidus*) with an arrow marking chromosome 7, the variable chromosome which is acrocentric in this species.



Figure 3. The karyotype of a female Ferruginous Hawk (*Buteo regalis*) with an arrow marking chromosome 7, the variable chromosome which is acrocentric in this species.

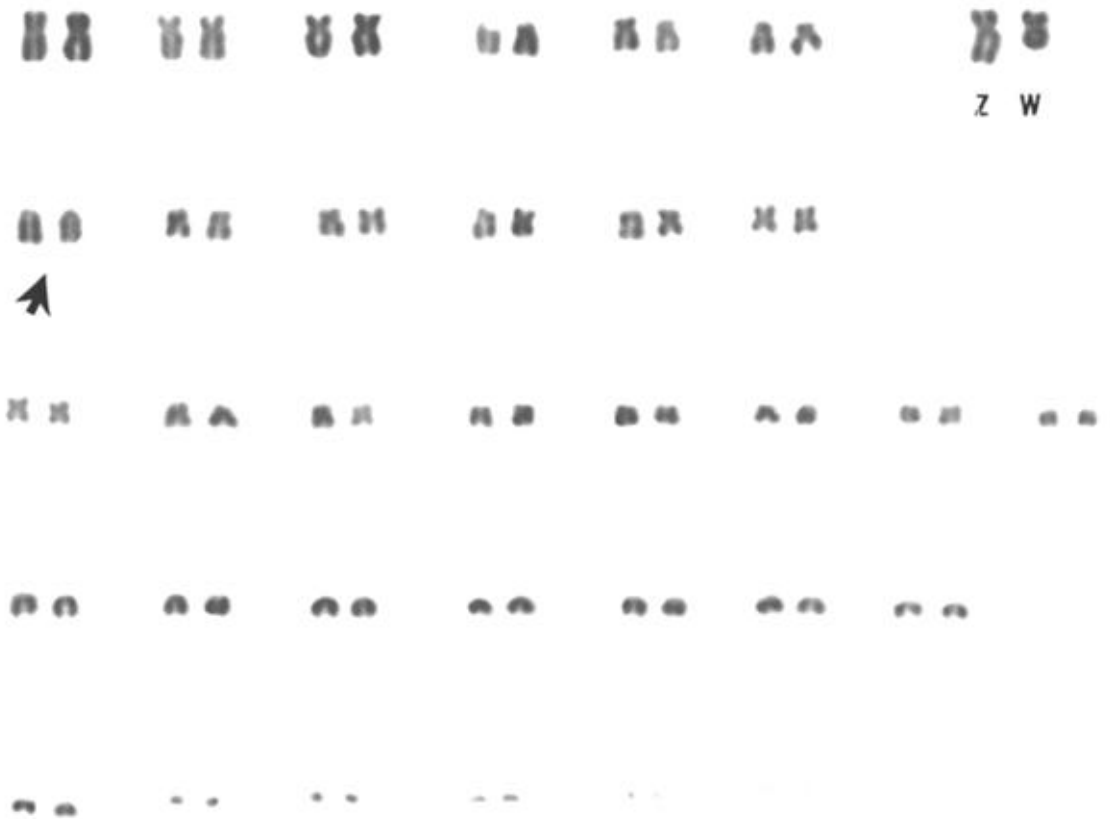


Figure 4. The karyotype of a female Harris' Hawk (*Parabuteo unicinctus*) with an arrow marking chromosome 7, the variable chromosome which is acrocentric in this species.



Figure 5. The karyotype of a female Broad-winged Hawk (*B. platypterus*). The karyotype is arranged to emphasize that chromosomes 16–20 in the middle row are acrocentric in this species as opposed to metacentric in the other buteos.

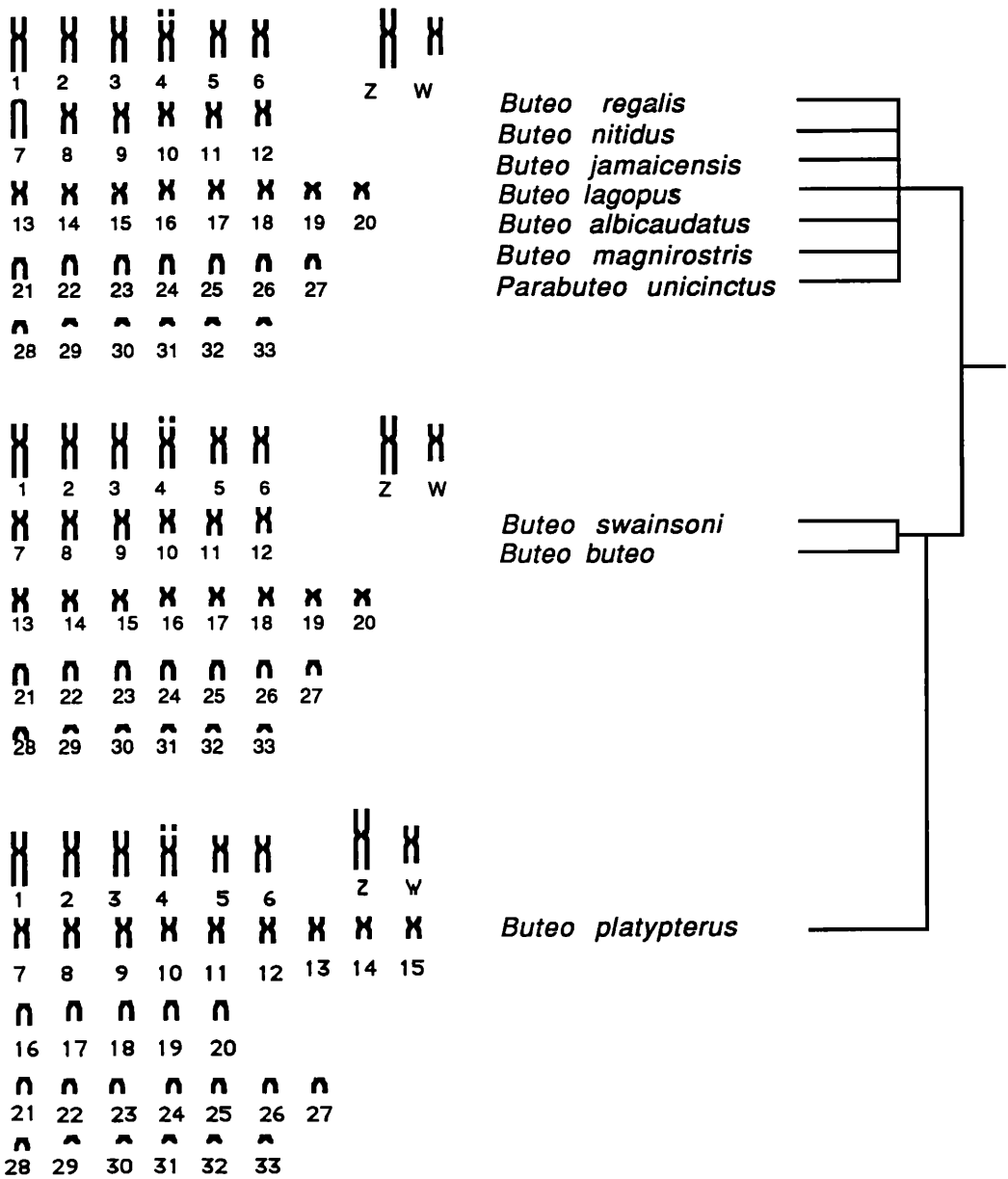


Figure 6. A cladogram illustrating the relationships among the buteonine hawks studied to date and computer drawn idiograms of the three karyotypes observed, upon which the phylogeny is based.

studied previously, although the copies of the karyotypes that we used make our interpretation tentative. The karyotypes of the Common Buzzard (*B. buteo*; De Boer 1976), the Red-tailed Hawk (*B. jamaicensis*; Stock and Worthen 1980), and the White-

tailed Hawk (*B. albicaudatus*; de Lucca 1985) match the buteos we did very closely. However, a minute metacentric was described (De Boer 1976, Stock and Worthen 1980) which we cannot verify or dispute since the small chromosomes in our karyotypes are

not elongated enough to determine this. We worked with poor photocopies of karyotypes of the Rough-legged Hawk (*B. lagopus*; Bulatova 1977) and the Roadside Hawk (*B. magistrostris*; de Lucca 1983) and can only say that the top two rows (Fig. 6) agree in general with the karyotypes of the buteos we studied.

DISCUSSION

Four species of buteonine hawks studied here for the first time have one of the same two karyotypes. This similarity supports the close taxonomic relationship Brown and Amadon (1968) suggested among these species. Further differentiation among subfamilies would need to be based on other types of data, such as DNA sequence data which is currently under investigation by Bob Sheehy (pers. comm.).

The difference in morphology of chromosome number 7 is likely due to an inversion, in this case a pericentric inversion, one of the two cytogenetic changes that typically occur during evolution (Hsu 1979). We are unable to say which is the "ancestral" shape of chromosome 7 and therefore our cladogram is "unrooted" and shows the two main branches as deriving at an equal point in time (Fig. 6).

The Harris' Hawk is placed in the genus *Parabuteo* as opposed to *Buteo*; however, its karyotype would not distinguish it from most of the other *Buteo* species studied to date. This suggests that the Harris' Hawk is indeed a close relative of the buteos.

In contrast the karyotype of the Broad-winged Hawk shows five chromosomes, numbers 16–20, that differ in morphology from the rest of the buteos (Fig. 5). This would suggest that it is the most divergent in the subfamily. It is more closely related to the Swainson's Hawk and Common Buzzard than the other buteos, based on the morphology of chromosome 7 (Fig. 6).

In contrast to the similarity found among the buteos, the nine species of falcons studied to date exhibit four different karyotypes in the genus (Schmutz and Oliphant 1987, Longmire et al. 1988). The primary cytogenetic differences among the falcons are centric fusions or translocations as opposed to inversions, with the Merlin (*Falco columbarius*) having the greatest number of chromosomes (Longmire et al. 1988) and therefore being the most diverged, followed by the Peregrine Falcon (*F. peregrinus*) and Prairie Falcon (*F. mexicanus*; Schmutz and Oliphant 1987).

Cytogeneticists frequently use banding of chro-

mosomes to demonstrate specific translocations and inversions in mammals (Ward et al. 1991). Avian karyotypes are much more difficult to obtain than mammalian karyotypes, primarily due to the lower numbers of dividing cells stimulated by mitogens (Prus and Schmutz 1987). Low numbers of dividing cells therefore make chromosome banding difficult since most techniques work well on only a small proportion of these cells. Although chromosome banding is necessary to determine with precision which chromosomes are involved in translocations, banding is not necessary to identify the presence or absence of translocations, which is the key to phylogenetic comparisons.

In addition to a poor response to mitogens, cytogenetic studies of birds have been further hampered because fresh blood samples or growing feathers, capable of further cell division in culture, are required for analysis. Many rare and endangered birds exist in remote areas. Field collection of samples from wild caught birds is occasionally possible but the logistics of air transport to an appropriate lab within 24 hr is frequently impossible. Despite such difficulties, chromosome analysis can provide a useful tool in taxonomic studies and we encourage raptor biologists to collaborate in such studies.

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